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Swertia hongquanii, a new species of Gentianaceae from Mt. Wuling, southern China

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Abstract

Swertia hongquanii Jia X. Li, a new species of Gentianaceae, is described and illustrated from Mt. Wuling, southern China. It grows on the tops of steep limestone mountains surrounded by cliffs above an altitude of ca. 1400 m. This species resembles *Swertia bimaculata*, but differs from the latter by the stem leaf blades 2.0–4.5 × 1.0–2.5 cm, ovate to ovate-cordate, base cordate and subamplexicaul, the seeds irregularly polyhedral and the seed coats minutely thorny and reticulate. Based on morphological traits, i.e. the inflorescence structure and the number and structure of the nectaries, the new species may be a member of series *Maculatae*. A key to the species of series *Maculatae* of section *Ophelia* is provided.

Keywords

Swertia, new taxon, limestone cliffs, Mt. Tianmen

Introduction

Mt. Wuling is located at the eastern edge of the Yunnan-Guizhou Plateau in southern China. This plateau has an ancient geological history and complex terrain and geomorphology (Zhu et al. 2015). Due to its long history and changing paleogeography, this area presents a great variety of physiographical characteristics and abundant diverse ecosystems within a short extent of space. Additionally, it has become an important channel for the concentration, diffusion and migration of east Asiatic angiosperms (Chen et al. 2002; Li et al. 2008; Li and Yu 2014; Zhu et al. 2015). Mt. Wuling is rich in flowering plants (4083 species: Chen et al. 2002) and several new taxa have been

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described from this area recently (e.g. Peng et al. 2007; Li and Yu 2014; Zhang et al. 2015; Liu et al. 2016). Here we propose another new species of *Swertia* L. (Gentianaceae), collected from Tianmenshan National Forest Park in this area.

Swertia consists of 3 subgenera, 11 sections and over 160 species (Joshi 2011; Rybczynski et al. 2014; Ho and Liu 2015). The genus is easily recognisable by the rotate corolla and by the presence of coralline nectariferous glands (Suksathan 2001; Ho and Liu 2015). The genus shows a North Temperate and South Temperate disjunctive (Pan-temperate) distribution pattern (Ho and Liu 2015). The majority of species are centred in Asia. South-western China and adjacent regions are diversity centres and initial diversification centres for this genus (Ho et al. 1994; Ho and Liu 2015). In China, approximately 75 species occur, mainly in mountains at an elevation above 1000 m (Ho and Pringle 1995). Moreover, several new species have been described from China since the account of the genus for the Flora of China was published (e.g. Chen et al. 2008; Ho and Liu 2010, 2015; Chen et al. 2016).

The new species from Mt. Wuling first came to our attention in September 2007 during our plant investigation in Tianmenshan National Forest Park. It was initially misidentified as *Swertia bimaculata* (Siebold & Zucc.) Hook.f. & Thomson ex C.B.Clarke due to its lax panicles of cymes and two naked nectaries per corolla lobe. In 2016, in the course of digitising the specimens in CSFI, we found a unique specimen, collected from Mt. Tianmen by Mr. Hongquan Huang (13050406) on 20 September 2013. It was identified as *Swertia bimaculata* but differs by its petite shape and cordate leaf base. Subsequently, we again visited Tianmenshan National Forest Park to observe this plant in September and November 2017 and collected more flowering and fruiting material. After a morphological comparison, the specimens from Tianmenshan National Forest Park are confirmed to be an undescribed species of *Swertia*, probably belonging to series *Maculatae* T.N.Ho & S.W.Liu in section *Ophelia* (Griseb.) Gilg in subgenus *Ophelia* (Griseb.) C.B.Clarke.

Materials and methods

During three field expeditions in September 2007, September and November 2017, a total of fifteen flowering and five fruiting individuals from the type locality were collected from Tianmenshan National Forest Park, Zhangjiajie City, Hunan Province, Southwest China. The information and measurements of the new species were taken from live and dried herbarium specimens and from field data. Seeds were examined and imaged with a Leica M205C stereomicroscope attached to a video camera (Leica DFC495). The morphological comparisons with related species, viz., *Swertia bimaculata*, *S. tashiroi* Makino, *S. oculata* Hemsl., *S. tozanensis* Hayata, *S. cordata* (Wall. ex G.Don) C.B.Clarke and *S. shintenensis* Hayata, are based on herbarium specimens (about 2300 specimens) and relevant literature (Ho et al. 1988; Ho and Pringle 1995; Rybczynski et al. 2014; Ho and Liu 2015). Specimens deposited in the following herbaria were examined: CSFI, CSH, CZH, JIU, HTC, IBK, IBSC, LBG, KUN, PE, SYS and WUK (Thiers 2015).

The number of mature individuals was recorded in the field in twenty 1 m^2 sampling plots. We assessed the preliminary conservation status of the new species using our field knowledge and applying the IUCN (2017) criteria. The taxonomic treatment of the genus *Swertia* follows Ho and Liu (2015).

Taxonomic treatment

***Swertia hongquanii* Jia X. Li, sp. nov.**
urn:lsid:ipni.org:names:60479372-2
Figs 1–3

Diagnosis. The new species is similar to *Swertia bimaculata*, but differs from the latter by its leaf blades ovate to ovate-cordate, 2.0–4.5 × 1.0–2.5 cm with base cordate and subamplexicaul (vs. broadly elliptic to ovate-lanceolate, 3.5–9 × 1.0–4 cm with base tapered to obtuse), and its seeds irregularly polyhedral with minutely thorny and reticulate seed coat (vs. globose with seed coat finely warty) (Table 1).

Type. CHINA. Hunan province: Zhangjiajie City, Mt. Tianmen, 29°3'N, 110°28'E, elev. 1400 m, 23 September 2016, *J. X. Li 092502* (holotype CSFI, bar code: CSFI063656; isotypes CSFI, IBSC, PE).

Description. Biennial herbs, 2–40 cm tall. Roots yellow, fibrous. Stems erect, sometimes branched from the lower part, subquadrangular, 1–3 mm in diam., with narrow wings on angles. Basal leaves quickly withering, blades elliptic to obovate, 1–3.5 × 0.8–3 cm, apex obtuse, base cuneate and decurrent, veins yellow-white, distinct, pinnate; petioles flattened, winged, ca. 0.5–2.5 cm long. Stem leaves sessile or

Table 1. Morphological comparison of *Swertia hongquanii*, *S. bimaculata*, and *S. cordata* (adapted from Ho and Liu 2015).

	S. hongquanii	***S. bimaculata***	***S. cordata***
Habit	biennial	annual or biennial	annual
Height	2–40 cm tall	30–140(–200) cm tall	15–40(–80) cm tall
Stem	1–3 mm in diam., simple or branched from the lower part	2–6 mm in diam., branched from the middle	1.5–2 mm in diam., branched at base or from the middle
Stem leaves	ovate to ovate-cordate, base cordate and subamplexicaul, 2.0–4.5 × 1.0–2.5 cm	broadly elliptic to ovate-lanceolate, base narrowly tapered to obtuse, 3.5–9 × 1–4(–5) cm	ovate to ovate-cordate, base cordate and subamplexicaul, 0.8–2.3 × 0.5–1.2 cm
Inflorescence	lax, axes and pedicels spreading, few or many-flowered, 5–20(–25) × 4–20 cm	lax, axes and pedicels spreading, many-flowered, 10–50 × 10–30 cm	compact, axes and pedicels not spreading, dense, many-flowered, 3–30(–40) × 2–10 cm
Pedicel length	0.6–4 cm	0.6–4 cm	0.3–1 cm
Corolla	white with purple spots, ca.20 mm in diam.	yellow or white, with purple spots, to 25 mm in diam.	pale purple, with dark purple veins, 10–15 mm in diam.
Nectaries	2 per corolla lobe, yellow-green, semi-orbicular, in the middle of corolla lobes	2 per corolla lobe, yellow-green, orbicular, in the middle of corolla lobes	1 per corolla lobe, yellow, rhomboid to orbicular, at the base of corolla lobes
Seeds	polyhedral, ca. 1.0 mm × 0.5 mm, seed coat minutely thorny and reticulate	globose, 1–1.5 mm in diam., seed coat finely warty	ellipsoid to globose, 0.8-1 mm in diam., seed coat longitudinally and thinly corrugate

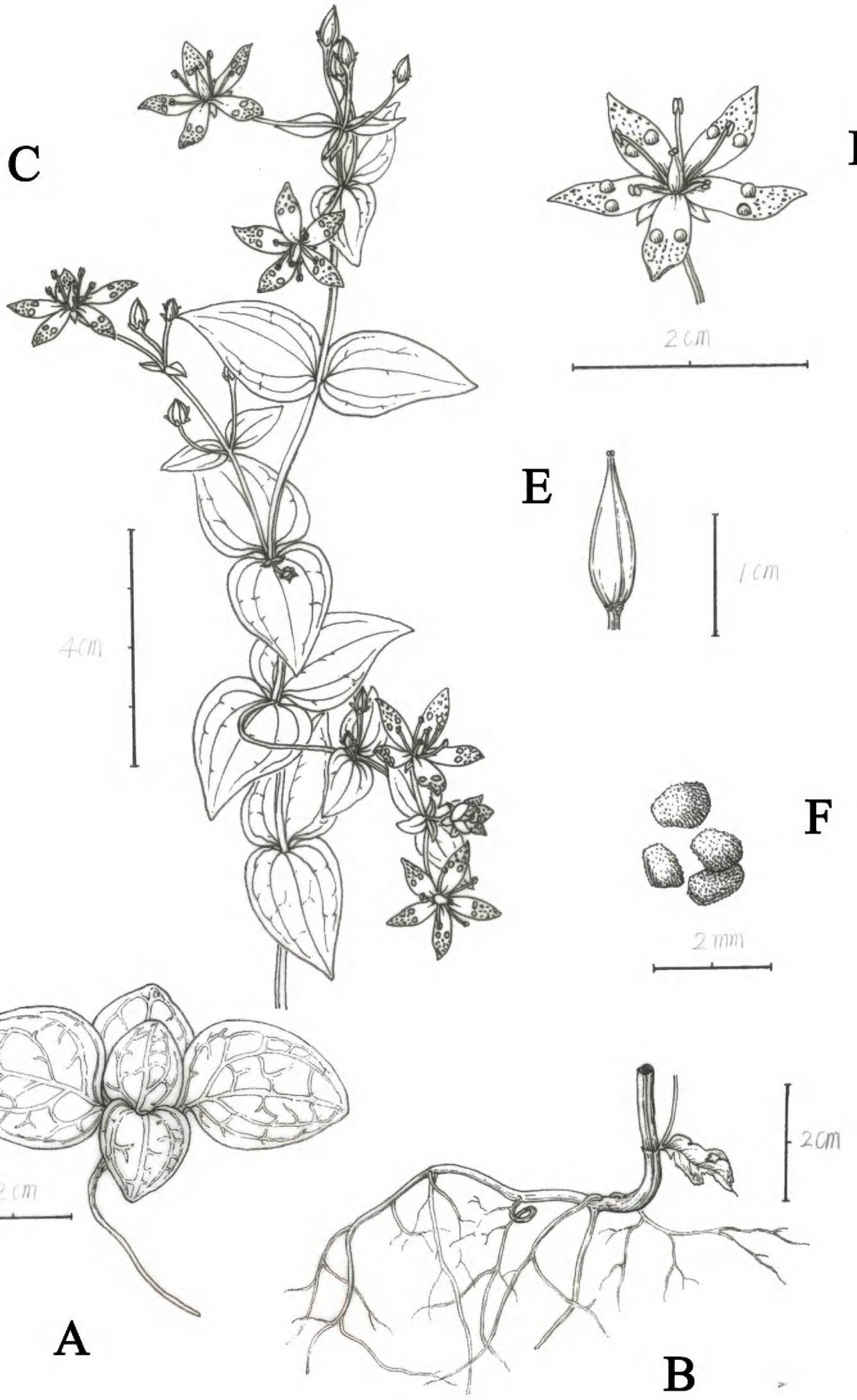

Figure 1. *Swertia hongquanii* **A** seedlings showing basal leaves **B** root **C** flowering plant **D** flower showing corolla, nectaries, stamens and pistil **E** capsule **F** seeds. Drawn by Jing Tian.

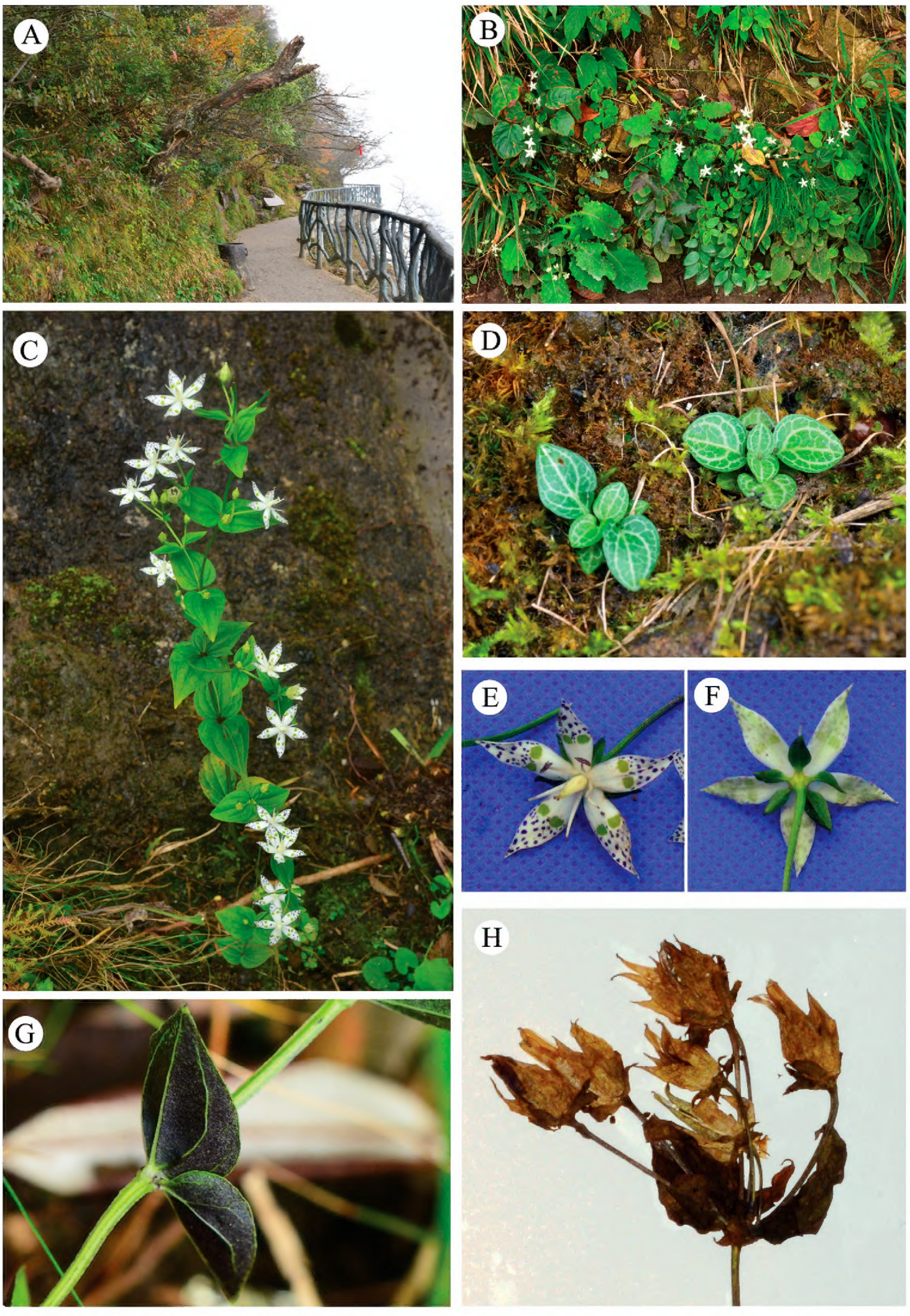

Figure 2. Habitat and morphology of *Swertia hongquanii*. **A–B** Habitat **C** flowering plant **D** seedlings showing basal leaves **E** adaxial view of flower showing calyx, corolla, nectaries, stamens and pistil **F** abaxial view of flower showing calyx and corolla **G** stem with a pair of leaves **H** flowering and fruiting plant; centrally, a capsule with persistent corolla can be seen. Photos: Jiaxiang Li.

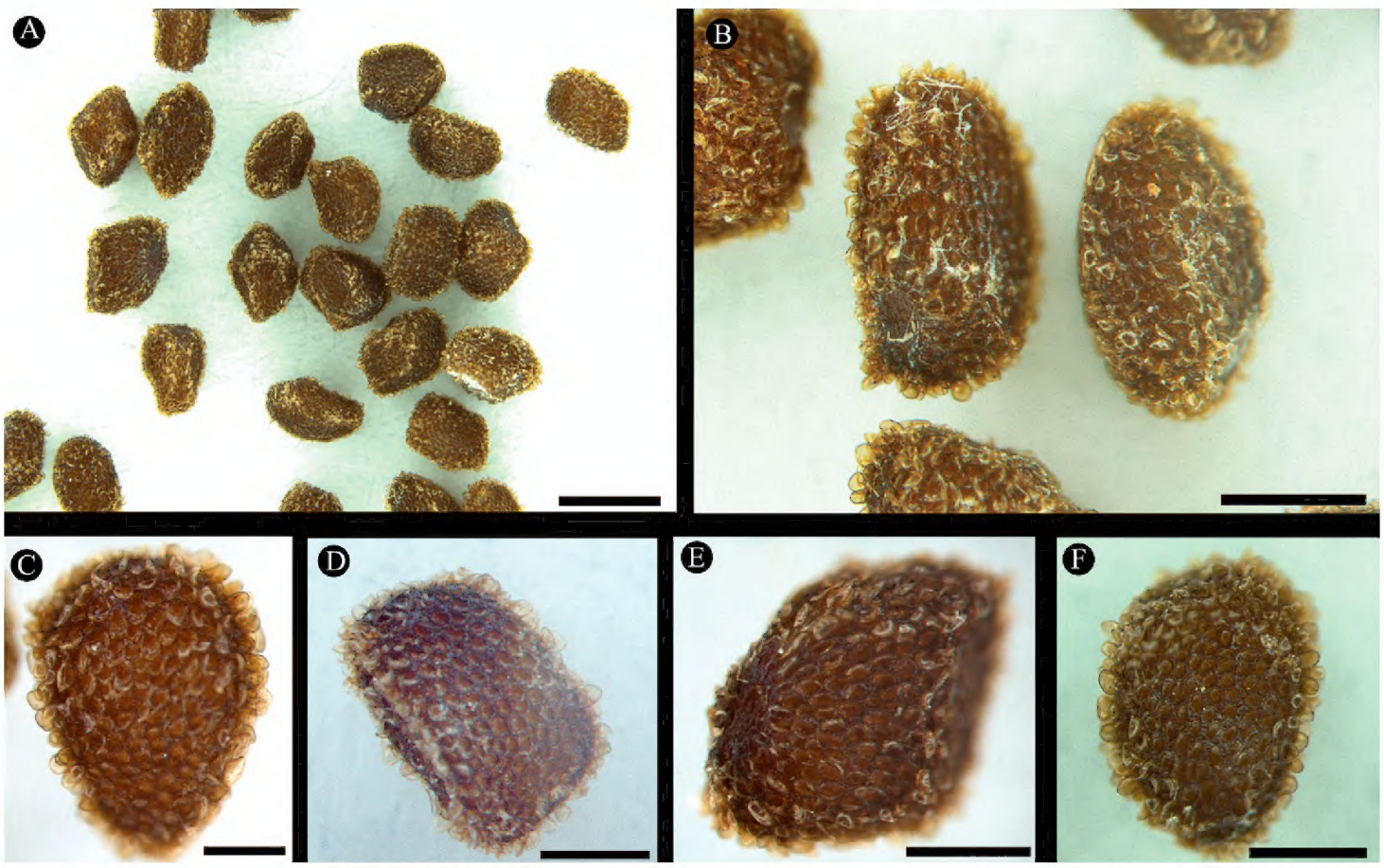

Figure 3. Seeds of *Swertia hongquanii*. Scale bars: 1 mm (**A**); 0.5 mm (**B**); 0.2 mm (**C**); 0.3 mm (**D–F**). Photos: Jiaxiang Li.

shortly petiolate, leaf blades ovate to ovate-cordate, apex acute, base cordate and subamplexicaul, 2.0–4.5 × 1.0–2.5 cm, smaller towards stem apex, veins 3–5, arcuate, distinct, green or yellow-green.

Inflorescence a panicle of cymes, lax, 5–20(–25) × 4–20 cm, few- or many-flowered; axes spreading. Flowers (4-)5-merous. Pedicels spreading to erect, slender, subquadrangular, 0.6–4 cm. Calyx 1/2 to 2/3 as long as corolla, tube 1–2 mm long, lobes narrowly elliptic, 3–6 mm long, with 3 slender and distinct veins, apex acute. Flowers to 2.0 cm in diam.; corolla white with purple spots on the upper half of the lobes adaxially but less visible abaxially, tube 1–2 mm long; lobes elliptic-lanceolate, 0.5–1.0 × 0.2–0.4 cm, widest at the middle, apex acuminate to acute. Nectaries 2 per corolla lobe, situated in the middle of corolla lobe, semi-circular, reduced to a naked gland patch without raised margin, yellow-green. Stamens with filaments ca. 4 mm long, white; anthers ellipsoid, ca. 1.5 mm long, purple. Style short, ca. 0.5 mm long; stigma lobes capitate. Capsules narrowly ovoid, to 1.3 cm long. Seeds polyhedral, compressed irregularly, with distinct angles, ca. 1.0 × 0.5 mm, dark brown; seed coat minutely thorny and reticulate.

Phenology. Flowering was observed in September and October. Fruiting was only observed in November, but probably extends till December.

Distribution and habitat. *Swertia hongquanii* is known only from the type location in Tianmenshan National Forest Park. The climate here is cool, foggy and humid (annual rainfall ca. 1700 mm) and belongs to the subtropical monsoon climate (Li et al. 2008; Zhang et al. 2015). The new species grows on the tops of steep limestone mountains surrounded by cliffs above an altitude of ca. 1400 m. The clifftops are covered by mixed evergreen-deciduous forest dominated by species of Fagaceae, Lauraceae, Betulaceae, Ac-

eraceae and Ulmaceae (Li et al. 2008). One population occurs in the crevices of limestone cliffs; it is covered by shrubs and herbs with little soil but is rich in humus. It is accompanied by *Viola davidii* Franch., *Youngia* Cass. sp., *Thalictrum ichangense* Lecoy. ex Oliv., *Aster ageratoides* Turcz., *Calamagrostis arundinacea* (L.) Roth, *Carex filicina* Nees, *Carex* L. sp., *Leptopus chinensis* (Bunge) Pojark., *Zanthoxylum bungeanum* Maxim., *Rubus innominatus* S.Moore var. *kuntzeanus* (Hemsl.) L.H.Bailey, *Rubus henryi* Hemsl. & Kuntze, *Salix mictotricha* C.K.Schneid., *Carpinus dayongiana* K.W.Liu & Q.Z.Lin and *Betula chinensis* Maxim. Another population grows in the herb layer of forest dominated by *Quercus multinervis* (W.C.Cheng & T.Hong) Govaerts and *Hovenia dulcis* Thunb. with deep and fertile soil. Other herbaceous species are *Ophiopogon japonicus* (Thunb.) Ker Gawl., *Carex gibba* Wahlenb., *Sanicula orthacantha* S.Moore, *Pimpinella diversifolia* DC. and *Viola diffusa* Ging.

Etymology. The species is named after Mr. Huang Hongquan for his help during our field investigation. He was also the first to collect this new species.

Local name. Tianmenshan Zhang Ya Cai

Conservation status. Despite several investigations in Mt. Tianmen and the surrounding areas (96 km^2), two populations with nearly 500 individuals each (total < 1000) of *Swertia hongquanii* were found only at the type locality (towering summit terrace with an area of 2 km^2). Presently, a tourist plank walkway passes through this location and its habitat could be easily disturbed or destroyed. According to the IUCN (2017) criterion D thresholds (mature individuals < 1000, AOO < 20 km^2), the new species could be assessed as VU. However, it grows in the upper part of steep limestone mountains surrounded by cliffs, which previously made it impossible to be encountered until a plank walkway was built across the cliff face for tourists. With limited fieldwork executed at present, it is possible that more populations could be found in similar habitats of the Wuling mountain areas. Therefore, we consider the species DD (Data Deficient).

Additional specimens examined. CHINA: Hunan, Zhangjiajie City, Mt. Tianmen, 20 September 2013, 29°3'N, 110°28'E, limestone, 1400 m alt., *Hongquan Huang* 13050406 (CSFI); the same locality, 20 November 2017, *Hongquan Huang* HHQ02 (CSFI); the same locality, 25 September 2017, J.X. Li 092503 (CSFI).

Discussion

Morphologically, *Swertia hongquanii* resembles *S. bimaculata* in possessing two naked gland patches in the middle of each corolla lobe, whereas it is clearly distinguished by stem leaf and seed characteristics (Table 1). During field investigations, we observed that most *S. bimaculata* flowers were withered while the new species was just beginning to blossom in populations in the same locality (separated by a distance of ca. 300 m). We therefore infer that the morphological differences with *S. bimaculata* are interspecific rather than intraspecific variations driven by ecological conditions.

From its overall vegetative appearance, *Swertia hongquanii* also resembles *S. cordata*, with both species having slender and subquadrangular stems with wings on the angles, ovate to ovate-cordate stem leaves with cordate to subamplexicaul bases. *Swertia hongquanii* is clearly distinguished from *S. cordata*, however, by the two nectaries in

the middle of the corolla lobes; *S. cordata*, in contrast, has a single nectary on the base of the corolla lobe (Table 1) (Ho and Liu 2015).

According to the classification of Ho and Pringle (1995) and Ho and Liu (1980; 2015), the species of series *Maculatae* of section *Ophelia* of subgenus *Ophelia* are distinguished by their stems being strongly branched, their inflorescences being panicles of cymes and by the presence of one or two nectaries on each corolla lobe reduced to a naked gland patch without raised margin. Six species, viz., *S. bimaculata*, *S. oculata*, *S. cordata*, *S. tozanensis*, *S. shintenensis* and *S. tashiroi* were recognised as members of series. *Maculatae*, distributed in Asia (Ho and Liu 2015). Based on morphological traits, especially those of inflorescences and nectaries, the new species may also be a member of series *Maculatae* (Figures 1–3).

The seeds of *S. hongquanii* are easily distinguished from other species of series *Maculatae*, as they are irregular polyhedrons with minutely thorny and reticulate seed coats (Figure 3), whereas those of the other species of series *Maculatae* are ellipsoid to globose with finely warty seed coats (*S. tashiroi*, *S. shintensis*, *S. bimaculata*, *S. tozanensis* and *S. oculata*) or with longitudinally and thinly corrugate seed coats (*S. cordata*) (Ho and Liu 2015).

Key to species of series Maculatae (adapted from Ho and Liu 2015)

1 Nectaries one per corolla lobe **2**
– Nectaries two per corolla lobe **3**
2 Basal leaves quickly withering; inflorescences usually narrow and dense; corolla pale purple; nectaries on base of corolla lobe; seed coat longitudinally and thinly corrugate ..... ***S. cordata***
– Basal leaves persistent; inflorescences rounded and lax; corolla yellow or yellow-green; nectaries in the middle of corolla lobe; seed coat finely warty **4**
3 Leaf blades broadly elliptic to ovate-lanceolate or ovate to ovate-cordate, more than 1 cm wide; corolla with purple spots **5**
– Leaf blades linear, linear-lanceolate or lanceolate, 0.2–0.7 cm wide; corolla with yellow-green or dark spots **6**
4 Upper stem leaves lanceolate to linear; corolla unspotted; seeds 0.5 mm in diam . ..... ***S. tashiroi***
– Upper stem leaves ovate; corolla with purple-brown spots on upper portion; seeds 0.7–1 mm in diam. ..... ***S. shintenensis***
5 Plants 30–140 (–200) cm tall; leaf blades broadly elliptic to ovate-lanceolate, base narrowly tapered to obtuse; seeds globose; seed coat warty ..... ***S. bimaculata***
– Plants 2–30 cm tall; leaf blades ovate to ovate-cordate, base cordate and subamplexicaul; seeds polyhedral; seed coat minutely thorny and reticulate ..... ***S. hongquanii***
6 Calyx lobes linear to linear-oblong; corolla lobes elliptic-lanceolate, white, with yellow-green spots, apex acuminate and apiculate ..... ***S. oculata***
– Calyx lobes ovate-lanceolate to spathulate; corolla lobes oblong, pale-yellow, with dark spots, apex obtuse to acute ..... ***S. tozanensis***

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References

Chen GX, Liao WB, Ao CQ, Liu WQ, Zhang HD (2002) Studies on character and feature of seed plants flora of Wulingshan region. Bulletin of Botanical Research 22(1): 98–120.

Chen CH, Chen CF, Yang SZ (2008) *Swertia changii* (Gentianaceae), a new species from Southern Taiwan. Botanical Studies (Taipei, Taiwan) 49: 155–160.

Chen BH, Wang JL, Chen SL (2016) *Swertia subuniflora* (Gentianaceae), a new species from Fujian, China. Phytotaxa 280(1): 36–44. https://doi.org/10.11646/phytotaxa.280.1.3

Ho TN, Liu SW (1980) New taxa of *Swertia* L. from China. Acta Phytotaxonomica Sinica 18(1): 75–85.

Ho TN, Liu SW (2010) Two new species of Gentianaceae from northwestern Yunnan, China. Novon 20(2): 166–169. https://doi.org/10.3417/2003046

Ho TN, Liu SW (2015) A worldwide monograph of *Swertia* and its allies. Science Press, Beijing, 430 pp.

Ho TN, Pringle JS (1995) Gentianaceae. Flora of China. Missouri Botanical Garden, St. Louis. 16, 139 pp.

Ho TN, Liu SW, Wu CJ (1988) Gentianaceae. Flora Reipubulicae Popularis Sinicae, vol. 62. Science Press, Beijing, 378 pp.

Ho TN, Xue CY, Wang X (1994) The origin, dispersal and formation of distribution pattern of *Swertia* L. (Gentianaceae). Acta Phytotaxonomica Sinica 32(6): 525–537.

IUCN (2017) Guidelines for using the IUCN red list categories and criteria. Version 13. Prepared by the standards and petitions subcommittee. http://www.iucnredlist.org/documents/RedListGuidelines.pdf

Joshi K (2011) Molecular differentiation and phylogeny of *Swertia* (Gentianaceae) of the Himalayan region, Nepal. International Journal of Biotechnology & Biochemistry 7: 265–277. https://doi.org/10.3732/apps.1700079

Li JX, Yu XL (2014) *Astragalus wulingensis* (Leguminosae), a new species from Hunan China. Phytotaxa 159(4): 279–286. https://doi.org/10.11646/phytotaxa.159.4.4

Li JX, Luo KW, Huang HQ, Mou C (2008) Additions novelty to the seed plants flora of Tianmen Shan, Zhangjiajie, Hunan Province. Journal of Tropical and Subtropical Botany 16(6): 573–576.

Liu H, Luo JL, Liu QY, Lan DQ, Qin R, Yu XL (2016) A new species of *Chrysosplenium* (Saxifragaceae) from Zhangjiajie, Hunan, central China. Phytotaxa 277(3): 287–292. https://doi.org/10.11646/phytotaxa.277.3.7

Peng CL, Yan LH, Huang HQ, Kang YQ (2007) *Rhododendron tianmenshanense* C.L.Peng & L.H.Yan, a new species of Ericaceae from Hunan, China. Acta Phytotaxonomica Sinica 45(3): 304–306.

Rybczynski JJ, Davey MR, Mikula A (2014) The Gentianaceae Volume 1: *Characterization and Ecology*. Springer, New York, 329 pp. https://doi.org/10.1007/978-3-642-54010-3

Suksathan P (2001) A new species of *Swertia* (Gentianaceae) from Thailand. Edinburgh Journal of Botany 58(3): 429–434. https://doi.org/10.1017/S0960428601000749

Thiers B (2015) Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium; Database. http://sweetgum.nybg.org/ih/

Zhang GJ, Hu HH, Zhang CF, Tian XJ, Peng H, Gao TG (2015) Inaccessible Biodiversity on Limestone Cliffs: *Aster tianmenshananensis* (Asteraceae), a new critically endangered species from China. PLoS One 10(8): e0134895. https://doi.org/10.1371/journal.pone.0134895

Zhu NH, Li JX, Zhang B (2015) The collection of precious and special plants in the Wuling Mountains area. Chinese Forestry Press, Beijing, 168 pp.